89-e39

Segment No. 23-59-02

WA-59-1010

COLVILLE WASTEWATER TREATMENT PLANT/COLVILLE RIVER RECEIVING WATER STUDY

by
G. J. Pelletier

Washington State Department of Ecology
Environmental Investigations and Laboratory Services Program
Surface Water Investigations Section
Olympia, Washington 98504

April 1989

ACKNOWLEDGMENTS

Tim Determan, currently with Ecology's Shorelands and Coastal Zone Management Program and formerly with Ecology's Surface Water Investigations Section, designed the study and conducted the field work. Joy Michaud, Ecology Surface Water Investigations, provided field assistance. Lynn Singleton and John Bernhardt provided valuable technical review and comments on the manuscript. Sonya Kirkendall typed and proofed the manuscript.

ABSTRACT

A receiving water study was conducted in the Colville River to evaluate the influence of the Colville Wastewater Treatment Plant (WTP) on water quality. The zone of effluent dilution was observed to occur over a relatively long distance (>300 feet) relative to Ecology guidelines. Potential dilution of the permitted discharge at 7-day, 10-year (7Q10) low river flow is less than Ecology guidelines (9:1 versus 100:1 guideline). Although the plant is presently not discharging at permit capacity, the existing permit loadings are expected to result in dissolved oxygen sags below the Class A standard and residual chlorine elevations above the chronic and acute aquatic life criteria at 7Q10 low river flow. Reduction in permitted loadings of BOD and residual chlorine are recommended at river flows less than 79 cfs, the 120-day, 2-year (120Q2) low flow, which generally occurs between July and November.

INTRODUCTION

Colville (population approximately 4,500) is served by a wastewater treatment plant (WTP) which discharges effluent to the Colville River at river mile 14.7 (Figure 1). The Colville WTP consists of a three-cell lagoon system. The first two cells are unaerated and the third has a 5-hp propeller aerator. Effluent is chlorinated, then held in a contact pond prior to discharge. Chlorinated effluent is then discharged to the Colville River through a surface ditch. Discharge to the Colville River is limited by Docket No. DE-77-281 modifying NPDES permit No. WA-002261-6.

The Colville River has been categorized as a water quality limited segment, according to Ecology's water quality index analysis for surface waters throughout the state (Hallock, 1988). The water quality index, which is a unitless number derived from ambient monitoring data, is intended to screen large numbers of stations for general water quality based on temperature, oxygen, bacteria, pH, turbidity, nutrients, suspended sediment, and ammonia toxicity. The Colville River station, which is located approximately 10 miles downstream from the Colville WTP, was considered to be water quality limited on the basis of unusually high temperature, bacteria, and turbidity.

The receiving water survey of the Colville River and a simultaneous Class II inspection of the WTP occurred during seasonal low flow (September 22-24, 1987). This report documents the receiving water survey. A separate report documents the WTP Class II inspection (Heffner, 1988). The major objectives of the receiving water survey were to determine the effect of the present discharge on water quality in the Colville River at low flow, and evaluate the WTP as a source of metals contamination in river sediments.

METHODS

The Colville WTP effluent enters the Colville River as a surface ditch on the right bank (facing downstream, north side of channel). Seven surface water sampling stations were selected (Figure 1) and sampled for a variety of chemical and physical parameters including temperature, pH, dissolved oxygen, specific conductance, chloride, total suspended solids,

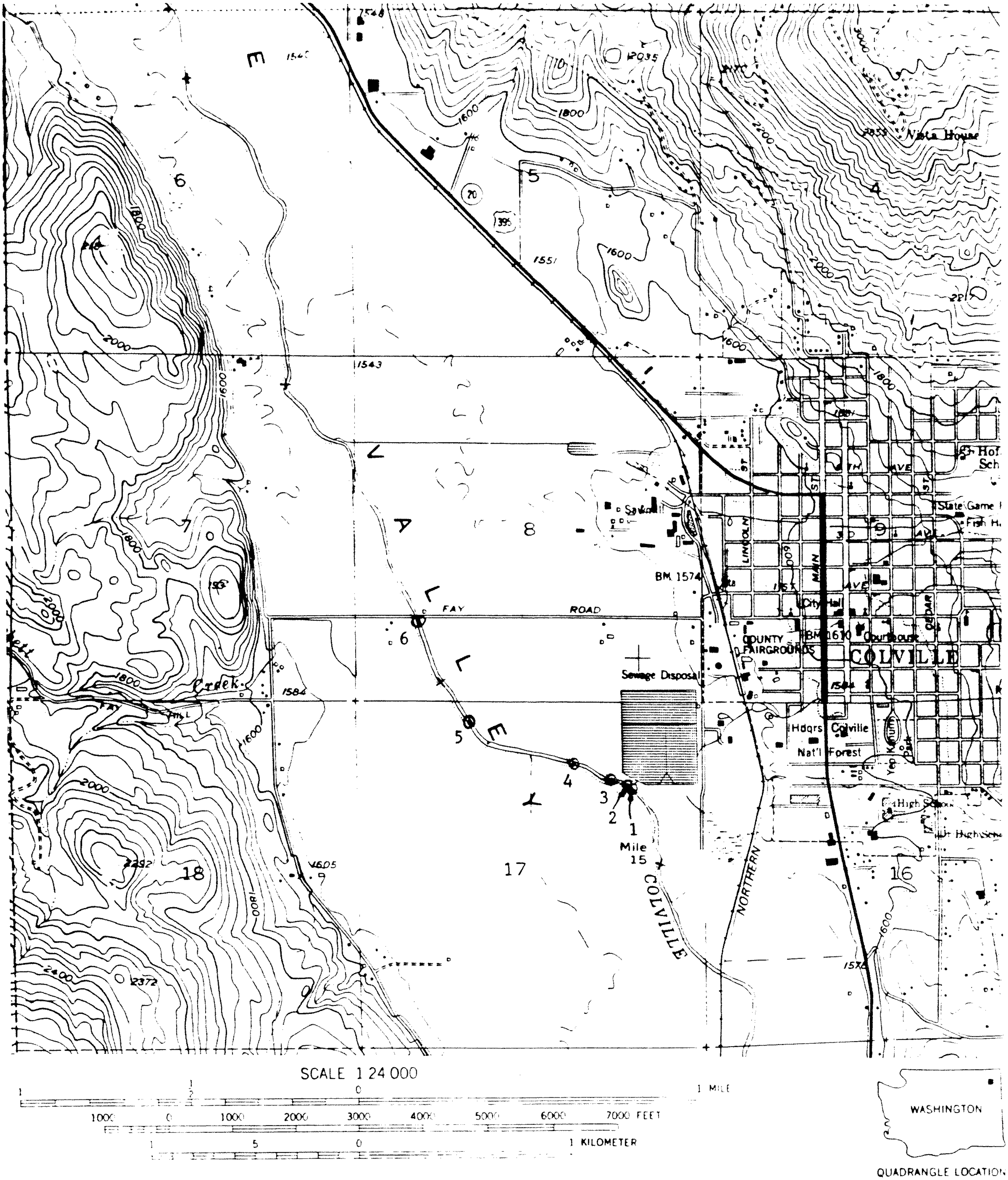


Figure 1. Surface water sampling stations for Colville WTP receiving water survey.

fecal coliforms, enterococci, nitrate + nitrite, ammonia, total phosphorus, turbidity, hardness, and metals. Chemical analyses were preformed by Ecology's Manchester Laboratory as per EPA (1983) and APHA *et al.* (1985) standard methods.

Water quality stations included one upstream station (station 1) and six downstream stations. Station 7 is Ecology's ambient monitoring station 59A070 located at r.m. 5.0, which is not shown on Figure 1. The water quality parameters listed above were sampled on two consecutive days of similar river flow for all parameters except metals, which were sampled on only one day. Stations 1, 2, and 3 each consisted of two sampling sites across the channel; one each near the right and left bank (designated as north and south, respectively). Each was located approximately five feet from the respective river banks (total river width approximately 50 feet). Supplemental measurements of conductivity were made at two additional cross-channel locations, each at stations 2 and 3, in order to identify the extent of the effluent plume. The other water quality stations (stations 4-7) were sampled at single mid-channel locations. In addition to water quality parameters listed above, sediment samples were collected from stations 1, 2, and 3 (north side only) and station 6 (mid-channel) for metals analysis.

Benthic macroinvertebrates were also sampled at stations 1, 3, and 6. Benthic samples were collected using a hand net. Five spots were sampled, spaced equally across the channel at each station. Sediment was disturbed within a marked area upstream from the net so that material would drift into the net. Material which was netted from each of the five cross-channel spots was pooled and picked for 10 minutes to obtain a composite sample from each station.

Two surveys of dissolved oxygen profiles between stations 1 and 6 were also conducted separately from other water quality sampling. The two dissolved oxygen surveys consisted of one early morning (5:30 to 6:30 a.m.; September 23, 1987) and one afternoon survey (3:40 to 4:40 p.m.; September 22, 1987), which were timed in order to characterize expected daily minimum and maximum dissolved oxygen levels in the river.

RESULTS AND DISCUSSION

Effluent Dilution. The effect of WTP loading on water quality is generally most critical during low flow when effluent dilution is lowest. Discharge in the Colville River varies widely by season (Figure 2). The period of lowest flow typically occurs during August and September. The distribution of effluent within the river was estimated based on observed elevations of chloride and specific conductance, both of which were considered to be conservative. The concentrations were much higher in effluent than in background river water.

Nearly complete mix of effluent was achieved approximately 1,000 feet downstream from the WTP input (Figure 3). A fairly high effluent percentage (greater than 35 percent) was observed near the north bank as far as 300 feet downstream (station 3-N, Figure 3). Dilution after complete mix was approximately 40:1 (approximately 2 percent effluent) based on comparison of total river flow with effluent discharge during the survey. Conditions during the survey were similar to 7-day low flow with a recurrence interval of once every two years (Table 1).

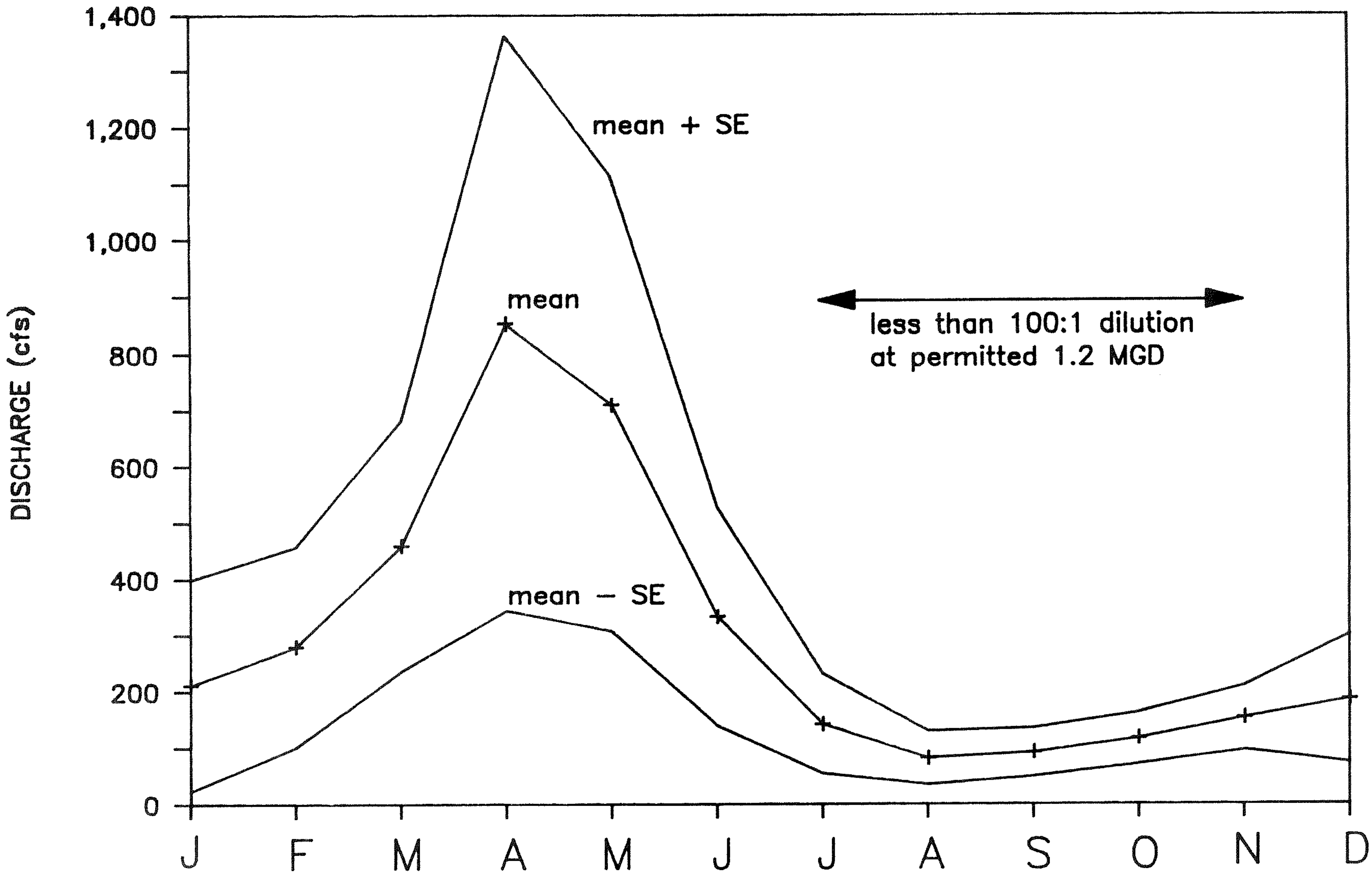


Figure 2. Monthly average discharge (mean ± std err) of the Colville River at Kettle Falls, 1923-1979 (USGS station 4090; r.m. 5.0).

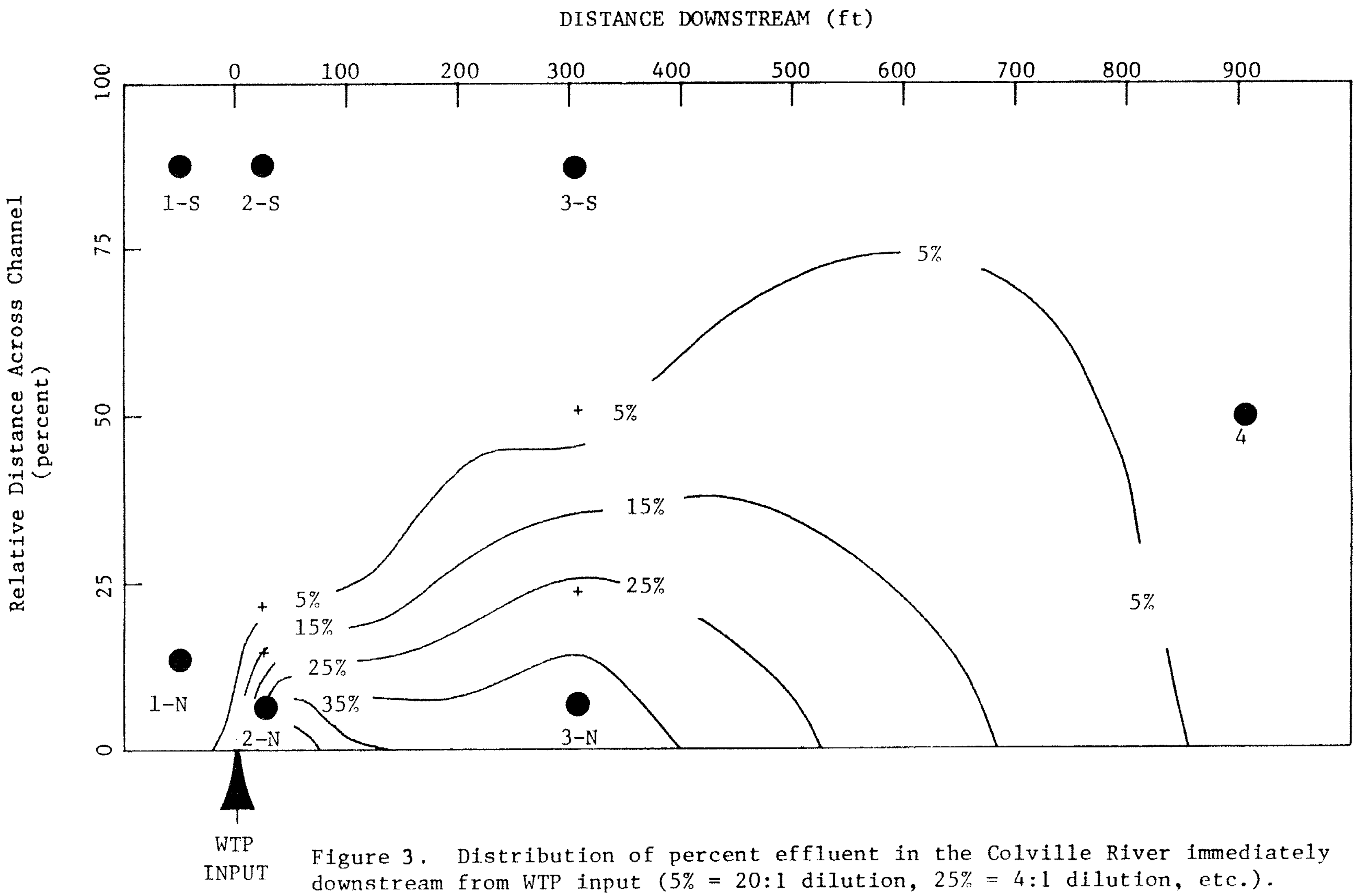


Figure 3. Distribution of percent effluent in the Colville River immediately downstream from WTP input (5% = 20:1 dilution, 25% = 4:1 dilution, etc.). Water quality sampling stations are shown by (●). Conductivity measurements were taken as shown by (+). Percent effluent was calculated by mass balance of chloride and conductivity data.

Table 1. Comparison of Colville River flow conditions with WTP discharge: Estimated effluent dilution for permitted discharge of 1.2 MGD (1.9 cfs).

Location	Low Flow Duration & Recurrence Interval (1)	Colville River Flow (cfs)	Effluent Dilution Based on WTP Discharge of 1.2 MGD (Dilution Ratio)	(Effluent Fraction)
Immed. Upstream from WTP (r.m. 15.3)	During Ecology Survey	46	--	--
Downstream from WTP (r.m. 13.8)	During Ecology Survey	50	27 : 1	3.6%
USGS Station 4090 (r.m. 5.0)	During Ecology Survey	55	30 : 1	3.3%
Immed. Upstream from WTP (r.m. 15.3)	183-day 2-year low flow	97	52 : 1	1.9%
	120-day 2-year low flow	79	43 : 1	2.3%
	90-day 2-year low flow	71	38 : 1	2.5%
	60-day 2-year low flow	64	34 : 1	2.8%
	30-day 2-year low flow	56	30 : 1	3.2%
	7-day 2-year low flow	50	27 : 1	3.6%
	7-day 5-year low flow	26	14 : 1	6.8%
	7-day 10-year low flow	16	9 : 1	10.2%

(1) m-day n-year low flow statistics refer to low flow events of m-day duration with a recurrence interval of n years. Flow statistics for USGS station 4090 (Williams and Pearson, 1985) were adjusted by the ratio of flow at Ecology station 1 (r.m. 15.3) to that observed at USGS station 4090 during Ecology survey (i.e., river discharge at WTP was approximately 84% of that at USGS station 4090).

General guidelines for effluent dilution (Ecology, 1985) recommend achievement of 100:1 dilution at low river flow conditions (7-day 10-year or 7Q10). Furthermore, the dilution zone should not extend farther than 300 feet downstream from the input or greater than 15 percent of the distance across the channel. For the permitted discharge of 1.2 MGD, the dilution would be only 9:1 after complete mix based on 7Q10 (Table 1). The dilution of effluent from the Colville WTP clearly does not meet the general guidelines for dilution zone boundaries or total dilution. Average monthly discharge for the months of July through November is insufficient to provide 100:1 dilution of effluent at permitted plant discharge of 1.2 MGD.

Receiving Water Quality. The results of general water quality analyses are presented in Tables 2 and 3. Of the parameters analyzed, only four were significantly elevated downstream from the effluent discharge after complete mix with river water. Both of the conservative tracers, chloride and specific conductance, were significantly elevated, as discussed above. Nitrate + nitrite and total P were also significantly elevated to levels which would be expected based on dilution of higher concentration effluent (Table 3). None of the conventional or bacteriological parameters measured were found in excess of criteria for aquatic life or drinking water maximum contaminant levels (MCL's). Unionized ammonia levels upstream from the WTP were estimated to be higher than downstream levels due to higher total ammonia, although the difference was not significant. None of the parameters observed downstream after complete mix deviated significantly from theoretical concentrations based on mass balance of upstream water with effluent discharge, which suggests that sampling adequately represented effluent impacts. However, conductivity and chloride data showed an increasing trend between Stations 4 and 7, which suggests that effluent mixing may not have been complete as far as 4,000 feet downstream from the input.

Ambient monitoring data have been collected at Ecology's station 59A070 since 1972. Observations during low flow months of August and September were compared with the downstream data from the current study. Significant differences were found between survey conditions and typical conditions for several parameters. Temperature, nitrate + nitrite, ammonia, un-ionized ammonia, and turbidity were all significantly lower during the current study than typical conditions during August and September (Table 3).

The depletion of dissolved oxygen (D.O.) downstream from WTP inputs is a common water quality concern. The two dissolved oxygen surveys revealed a depression of D.O. immediately downstream from the discharge (Figure 4). The observed decrease in D.O. can be explained by dilution of low D.O. effluent with higher D.O. river water. Significantly lower D.O. concentrations were observed only in northern stations (2-N and 3-N), which contained greater than 35 percent effluent. No discernible sag in D.O. was evident due to decay of BOD inputs from the WTP.

A model of BOD decay and dissolved oxygen sag was run based on the Streeter Phelps approach (Mills *et al.*, 1985), which indicated that maximum oxygen deficit is expected immediately after complete mix of effluent with river water under the conditions of the Ecology Survey. Natural processes in the stream, including reaeration, photosynthesis, and respiration, appeared to exert a greater influence on D.O. concentration than BOD decay of WTP inputs. In general, the depletion from BOD load is much less than the reaeration rate

Table 2. Colville River receiving water study water quality data, September 1987.

Date	Time	Station	Distance Downstream from WTP input (ft.)	Flow (cfs)	Temp. (°C)	pH (S.U.)	Diss. Oxygen (mg/L)	Total Resid. Chlorine (mg/L)	Chloride (mg/L)	Spec. Cond. (um/cm. @ 25°C)	Total Susp. Solids (mg/L)	Hardness (mg/L as $CaCO_3$)	Fecal Coliform (#/100 mL)	Enterococci (#/100 mL)	Nitrate + Nitrite N (mg N/L)	Ammonia N (5) (mg N/L)	Un-ionized Ammonia N (ug N/L)	Total Phos. (mg P/L)	Turbidity (NTU)
Sept																			
23	1135	1-N	--	46	14.3	8.2	10.2	--	2.8	349	11	160	29	32	0.02	0.05	1.9	0.06	4
24	0900			--	12.2	--	--	--	3.6	352	21	170	110	--	0.02	0.07	2.3	0.07	7
23	1145	1-S		46	14.0	8.2	10.1	--	2.5	345	12	170	24	49	0.01	0.01 K(1)	0.2	0.04	3
24	0855			--	12.2	--	--	--	3.0	345	22	160	83	--	0.02	0.01 K	0.2	0.05	8
23	1107	2-N	15	--	14.4	8.3	7.1	--	44	626	15	230	51	280	0.37	0.33	15.8	1.2	5
24	0845			--	13.1	--	--	--	43	613	18	220	73	--	0.25	0.28	12.2	0.90	6
23	1125	2-S		--	13.9	8.3	10.1	--	3.3	346	13	160	33	57	0.02	0.01 K	0.2	0.04	4
24	0850			--	12.2	--	--	--	4.1	346	28	160	120	--	0.02	0.01 K	0.2	0.05	8
23	1052	3-N	300	--	14.1	8.3	8.8	--	36	581	17	250	49	100	0.19	0.27	12.6	0.70	5
24	0830			--	12.9	--	--	--	34	569	22	200	73	--	0.20	0.25	10.7	0.73	7
23	1050	3-S		--	13.6	8.2	9.9	--	2.6	347	14	160	66	72	0.02	0.01 K	0.2	0.04	4
24	0835			--	12.2	--	--	--	2.4	344	24	170	84	--	0.02	0.01 K	0.2	0.05	8
23	1035	4	900	--	13.3	8.2	10.1	--	2.8	348	20	190	61	48	0.02	0.01	0.4	0.05	5
24	0855			--	12.0	--	--	--	5.8	360	23	170	100	--	0.03	0.03	1.0	0.10	7
23	1021	5	2,900	--	13.8	8.1	10.0	--	3.4	353	15	190	47	43	0.02	0.01	0.3	0.08	4
24	0845			--	11.8	--	--	--	4.4	352	28	160	80	--	0.03	0.02	0.5	0.07	9
23	0915	6	3,900	50	11.8	8.3	9.6	--	5.2	367	20	180	40	67	0.02	0.03	1.1	0.08	5
24	0811			--	--	--	--	--	8.8	361	21	160	92	--	0.03	0.03	1.1	0.09	8
23	0835	7	51,000	54	14.8	8.3	8.4	--	4.5	378	29	200	110	80	0.04	0.01 K	0.3	0.06	6
24	0952			56	15.0	--	--	--	5.4	375	9	150	60	--	0.05	0.01 K	0.3	0.05	4
22	1120	Effluent	--	1.0	17.5	8.3	--	<0.1	--	990	--	--	--	--	--	--	--	--	--
	1530			1.1	18.5	8.9	--	--	--	1050	--	--	--	120	--	--	--	--	--
23	0750			0.63	--	--	--	--	--	--	--	--	4	110	--	--	--	--	--
	1055			--	16.5	--	--	--	--	1000	--	--	3	--	--	--	--	--	--
	1100			0.63	14.9	8.4	6.0	--	87	918	23	310	34	140	0.50	0.44	--	1.8	7
	24-hr comp.			0.76	--	--	--	--	110	997	52	305	--	--	0.03	0.51	--	2.4	10
24	0825			--	14.5	--	--	--	88	919	16	290	27	--	0.50	0.46	--	1.8	7
WATER QUALITY CRITERIA/STANDARDS																			
Acute Aquatic Life					--	--	>3.0	0.019	--	--	--	--	--	--	--	--	210(3)	--	--
Chronic Aquatic Life					--	6.5-9.0	>4.0	0.011	--	--	--	--	--	--	--	--	41(3)	--	--
Drinking Water MCL					--	--	--	--	--	--	--	--	--	--	10.000	--	--	--	--
Class A Standard(2)			-		<18.0	6.5-8.5	>8.0	--	--	--	--	--	100/200	--	--	--	--	--	10.5
Freshwater Bathing(2)				--	--	--	--	--	--	--	--	--	--	33/108	--	--	--	--	-

FOOTNOTE:

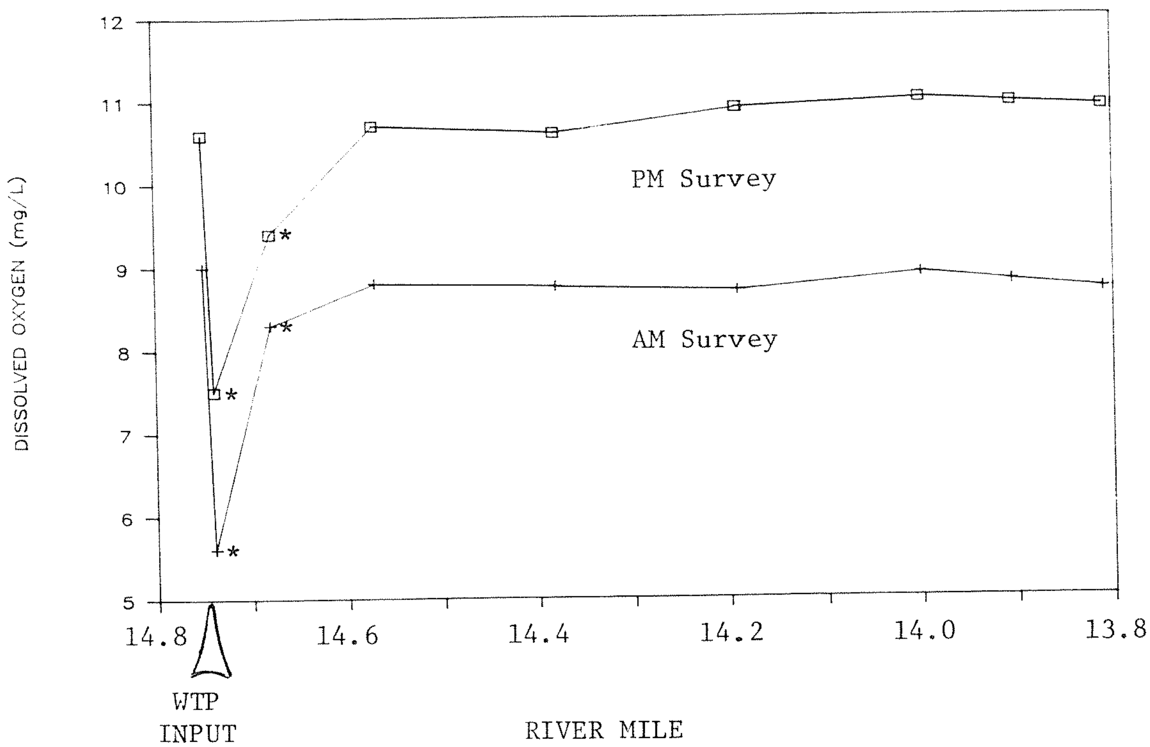
(1) "K" indicates sample level below lower limit of detection.
(2) Bacteria standards given are for geometric mean and upper 10 percentile.
(3) Un-ionized ammonia criteria is based on temperature 21°C and pH = 8.0.

Table 3. Colville River receiving water study: summary of water quality data.

Location	Temp. (°C)	pH (S.U.)	Diss. Oxygen (mg/L)	Total Chlorine Resid. (mg/L)	Chloride (mg/L)	Spec. Cond. (um/cm @ 25°C)	Total Susp. Solids (mg/L)	Hardness (mg/L as $CaCO_3$)	Fecal Coliform (#/100 mL)	Enterococci (#/100 mL)	Nitrate + Nitrite N (mg N/L)	Ammonia N (7) (mg N/L)	Un-ionized Ammonia N (ug N/L)	Total Phos. (mg P/L)	Turbidity (NTU)
UPSTREAM CONDITIONS (1)															
Mean (2)	13.2	8.2	10.2	--	3.0	347.8	16.5	165.0	50	40	0.018	0.033	1.2	0.055	5.5
Worst 10 Percentile (2)	14.6	8.2	10.2	--	3.6	352.1	23.9	172.4	132	58	0.024	0.075	2.6	0.072	8.6
Std Error (2)	0.6	0.0	0.0	--	0.2	1.7	2.9	2.9	21	21	0.002	0.016	0.6	0.006	1.2
N	4	2	2	--	4	4	4	4	4	2	4	4	4.0	4	4
DOWNSTREAM CONDITIONS (1)															
Mean (2)	13.2	8.2	9.5	--	5.0	361.8	20.6	175.0	70	58	0.030	0.017	0.6	0.073	6.0
Worst 10 Percentile (2)	15.0	8.3	10.5	--	7.4	375.7	29.0	197.7	111	83	0.044	0.032	1.1	0.096	8.4
Std Error (2)	0.5	0.0	0.4	--	0.6	3.9	2.3	6.3	9	18	0.004	0.004	0.1	0.006	0.7
N	7	4	4	--	8	8	8	8	8	4	8	8	8.0	8	8
Significant Difference? (3)	NO	NO	NO	--	*YES*	*YES*	NO	NO	NO	NO	*YES*	NO	NO	*YES*	NO
EFFLUENT CONCENTRATION															
Mean	16.4	8.5	6.0	<0.1	95.0	979	30.2	302	17	123	0.343	0.470	42.1	2.000	8
Std Err	0.8	0.2	--	--	7.5	21	10.9	6	8	9	0.157	0.021	1.9	0.200	1
N	5	3	1	1	3	6	3	3	4	3	3	3	--	3	3
THEORETICAL DOWNSTREAM CONCENTRATION AFTER MIXING (4)															
Mean (2)	--	--	--	--	--	363.2	16.8	168.3	49	41.6	0.025	0.043	1.6	0.102	5.6
Std Error (2)	--	--	--	--	--	14.4	2.9	5.5	20	20.7	0.007	0.017	0.7	0.029	1.2
Significant Difference? (5)	--	--	--	--	--	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
AMBIENT MONITORING DATA AUGUST-SEPTEMBER, 1972-87															
Mean (2)	17.5	8.0	8.9	--	--	347	13.4	--	68	--	0.212	0.055	1.7	0.069	12
Worst 10 Percentile (2)	21.5	8.6	10.2	--	--	399	20.8	--	230	--	0.450	0.107	3.4	0.108	27
Std Error (2)	0.6	0.1	0.2	--	--	8	1.4	--	--	--	0.048	0.008	0.3	0.006	2
N	27	23	26	--	--	26	17	--	24	--	15	26	26	26	25
Significant Difference? (6)	*YES*	NO	NO	--	--	NO	NO	--	NO	--	*YES*	*YES*	*YES*	NO	*YES*
WATER QUALITY CRITERIA/STANDARDS															
Acute Aquatic Life	--	--	>3.0	0.019	--	--	--	--	--	--	--	--	210(8)	--	--
Chronic Aquatic Life	--	6.5-9.0	>4.0	0.011	--	--	--	--	--	--	--	--	41(8)	--	--
Drinking Water MCL	--	--	--	--	--	--	--	--	--	--	10.000	--	--	--	--
Class A Standard(7)	<18.0	6.5-8.5	>8.0	--	--	--	--	--	100/200	--	--	--	--	--	10.5
Freshwater Bathing(7)	--	--	--	--	--	--	--	--	--	33/108	--	--	--	--	--

FOOTNOTES:

1. Upstream condition assumed to be average of station 1-N and 1-S, downstream based on average of stations 4, 5, 6 and 7.
2. Mean and worst 10 percent based on normal distribution, except fecal coliform and enterococci based on log-normal.
3. Significant difference between upstream and downstream based on 95% confidence (t-test).
4. Theoretical concentration based on effluent fraction determined by chloride mass balance and calculated mixture of upstream and effluent concentrations.
5. Significant difference between survey downstream conditions and theoretical mixed river based on mass balance of effluent and upstream water (95% confid; t-test)
6. Significant difference between survey downstream conditions and ambient monitoring data for August-September data (95% confidence; t-test).
7. Bacteria standards given are for geometric mean and upper 10 percentile.
8. Un-ionized ammonia criteria based on temperature = 21°C and pH = 8.0



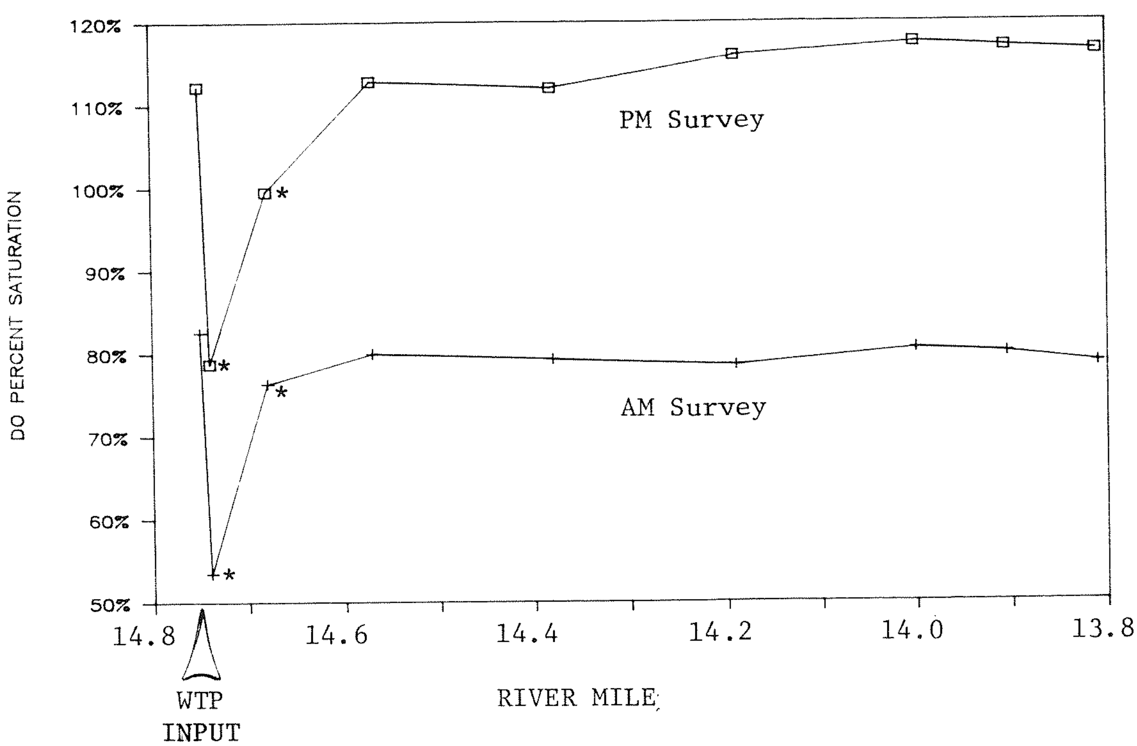


Figure 4. Profiles of Dissolved Oxygen During Morning (AM) and Afternoon (PM) Surveys in the Colville River, September 22-23, 1987. The right bank only was sampled at stations 2 and 3, as indicated by (*). Other stations were sampled at mid-channel.

based on typical rate constants. The comparison of morning and afternoon D.O. levels indicates a diurnal pattern of low morning D.O. due to overnight respiration, followed by afternoon elevations in excess of saturation probably caused by photosynthesis. Further examination of predicted worst-case D.O. conditions is presented below for permitted BOD loadings and various river discharges.

Of the metals analyzed, only hexavalent chromium, copper, nickel, and zinc were detected in the WTP effluent (Table 4). For the metals detected, the levels in effluent were higher than upstream background conditions. The elevations observed downstream from the effluent discharge were similar to the expected values based on effluent dilution, which suggests that observed elevations were caused by the effluent input (Table 4). The concentrations observed in the river downstream from effluent discharge, and even in the full-strength effluent, were below water quality criteria for aquatic life and drinking water MCL's, as well as human health criteria.

The metals concentrations observed in the Colville WTP effluent were generally lower than expected values from domestic wastewater in Washington, assuming typical removal efficiencies in the lagoon system (Hallinan, 1988; Mills *et al.*, 1985). However, since the variability of typical values is high and only one sample was collected from the Colville WTP, it is not possible to determine whether Colville effluent is significantly different from typical effluent. Nevertheless, Colville WTP effluent does not appear to be unusually high in metals concentrations, although more samples would be required to confidently characterize metals loads to the Colville River.

Total Maximum Daily Load Analysis. The current NPDES permit limitations for effluent discharge are presented in Table 5. The treatment plant was in compliance with the permit limitations during the Ecology Class II inspection, with the exception of low residual chlorine. Also, one out of two pH measurements exceeded the permit range. The permit limitations for 5-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS) are less stringent than typical effluent limits for domestic wastewater facilities which discharge to surface waters (Table 5). The Colville WTP discharge is limited by Docket No. DE-77-281 which relaxes NPDES Permit No. WA-002261-6. A moderate worst-case evaluation of water quality impacts on the Colville River was performed, based on permitted weekly average effluent characteristics and various low river discharges. Absolute worst-case conditions of a possible plant upset during low river flow were not evaluated but are possible concerns when low dilution ratios are present.

Dissolved oxygen depletion downstream from the WTP input was predicted for a range of conditions based on the Streeter-Phelps model (Mills, *et al.*, 1985). The model input assumptions are presented in Appendix A. D.O. depletion downstream from the WTP input was predicted for a range of river discharges at permitted weekly BOD loading of 1000 lbs./day (Table 6). The range of river flows evaluated was chosen to represent a range of low flow durations that occur once every two years, based on log-Pearson Type III analysis (Williams and Pearson, 1985).

Table 4. Colville River receiving water study: metals data (1); September 1987.

Date	Time	Station	Total Recoverable Cadmium (ug/L)	Total Recoverable Chromium (ug/L)	Total Hexavalent Chromium (ug/L)	Total Recoverable Copper (ug/L)	Total Recoverable Lead (ug/L)	Total Recoverable Nickel (ug/L)	Total Recoverable Zinc (ug/L)
23	1135	1-N	0.2 U	5 U	--	3	5 U	5 U	1
23	1107	2-N	0.2 U	5 U	1 U	8	5 U	17	5
23	1052	3-N	0.2 U	5 U	1 U	6	5 U	8	5
23	1100	WTP Effluent	0.2 U	5 U	2	6	5 U	26	4
23		Transfer Blank	0.2 U	5 U	1 U	1 U	5 U	5 U	1 U
PREDICTED DOWNSTREAM CONCENTRATION AFTER MIXING (2)			0.2 U	5 U	--	4	5 U	11	2
TYPICAL LAGOON EFFLUENT (3)			0.3-<11	2-100	--	16-440	10-250	4-90	30-330
WATER QUALITY CRITERIA/STANDARDS									
		Acute Aquatic Life	8	2,800	16	31	175	2,400	200
		Chronic Aquatic Life	2	340	11	20	7	260	180
		Drinking Water MCL	10	50	50	--	50	--	--
		Human Health Criteria	10	170,000	50	1,000	50	--	--

FOOTNOTES:
1) Data qualifier "U" indicates sample level was below lower limit of detection.
2) Theoretical concentration based on effluent fraction determined by chloride mass balance and calculated mixture of upstream and effluent concentrations.
3) Based on typical values found in influent to municipal WTPs in Washington (Hallinan, 1985) and typical lagoon treatment efficiency (Mills, et al., 1985).

Table 5. NPDES permit comparison - Colville, September 1987.

Parameter	Permit Limits*		Inspection Data**			Typical Secondary Treatment Limits	
	Monthly Average	Weekly Average	Ecology Composite	WTP Composite	Grab Samples	Monthly Average	Weekly Average
BOD_5							
(mg/L)	60	100	20	38	--	30	45
(lbs/D)	600	1000	82	155	--	--	--
TSS							
(mg/L)	60	100	33	70	--	30	45
(lbs/D)	600	1000	135	286	--	--	--
Chlorine residual (mg/L)	0.1 - 0.5		--	--	<0.1	--	--
pH (S.U.)	6.5 - 8.5		--	--	8.3, 8.9	6 - 9	
Fecal coliform (#/100 mL)	200+	400+	--	--	4, 3	200	400
Flow (MGD)	1.20		0.49	0.49	--	--	--

*limits as modified by Docket #DE 77-281
**calculated using Ecology analytical results
+parameter included in NPDES permit (#WA-002261-6), but not in Docket

The D.O. sag model was used to predict a permissible effluent BOD concentration that would maintain D.O. concentrations at or above the Class A standard for the permitted effluent discharge rate (Figure 5; Driscoll *et al.*, 1983). The 7Q10 river discharge is predicted to result in D.O. deficit of approximately 2.9 mg/L due to the presently permitted BOD loading of 1000 lbs./day. Therefore, downstream D.O. concentrations are predicted to drop below the Class A standard of 8 mg/L to approximately 5.6 mg/L at the 7Q10 low flow condition under the existing permit. The BOD concentration in the effluent would need to be reduced to 6 mg/L at the permitted discharge rate in order to maintain the Class A standard at 7Q10 low flow. The D.O. analysis indicates that the existing permit would result in D.O. depletion below the Class A standard during seasonal low river flow, even at river flows as high as 97 cfs (183Q2) (Table 6). The monthly average permit limits of effluent BOD_5 (60 mg/L; 600 lbs./day) are predicted to result in violation of Class A standards at river flows less than 79 cfs (120Q2). Therefore, maintenance of the Class A standard would require a reduction of permitted BOD loading at river flows less than 79 cfs (120Q2).

Assuming that effluent BOD concentrations were reduced to 30 mg/L, which is the typical concentration for secondary treatment, effluent BOD loading would be 300 lbs./day at the permitted discharge rate of 1.2 MGD. The Class A D.O. standard would be maintained at river flows above 56 cfs (30Q2) at this assumed loading. Therefore, diversion of effluent would be required even with effluent BOD concentrations reduced to typical secondary treatment levels at river flows less than 56 cfs (30Q2). The acceptable effluent BOD load, which would maintain the Class A D.O. standard at the 7Q10 low river flow, is 57 lbs./day (Table 6). Therefore, a diversion of approximately 90 percent of the currently permitted load or 80 percent of the load from the currently permitted discharge at an assumed 30 mg/L BOD concentration, would be required.

The concentrations of fecal coliform bacteria, residual chlorine, un-ionized ammonia, copper, nickel, and zinc were also estimated for 7Q10 river discharge and permitted effluent loadings (Table 7). Fecal coliform bacteria levels are predicted to meet the Class A water quality standard at 7Q10 river flow and permitted effluent loading.

Residual chlorine is predicted to exceed the aquatic life criteria at permitted effluent concentrations of 0.1 to 0.5 mg/L at permitted effluent discharge of 1.2 MGD and 7Q10 low river discharge. River flows below 79 cfs (120Q2) would result in downstream residual chlorine in excess of the chronic aquatic life criteria for the permitted effluent concentration of 0.5 mg/L.

Un-ionized ammonia concentrations are predicted to meet acute and chronic aquatic life criteria at 7Q10 low river flow at the permitted effluent discharge rate, assuming existing effluent ammonia concentrations and ambient river conditions of temperature and pH remain constant.

Selected priority pollutant metals (copper, nickel, and zinc) are predicted to remain below acute and chronic aquatic life criteria at 7Q10 low river flow, at permitted effluent discharge rates, assuming that existing effluent metals concentrations during the Ecology survey represent future concentrations at the permitted discharge rate.

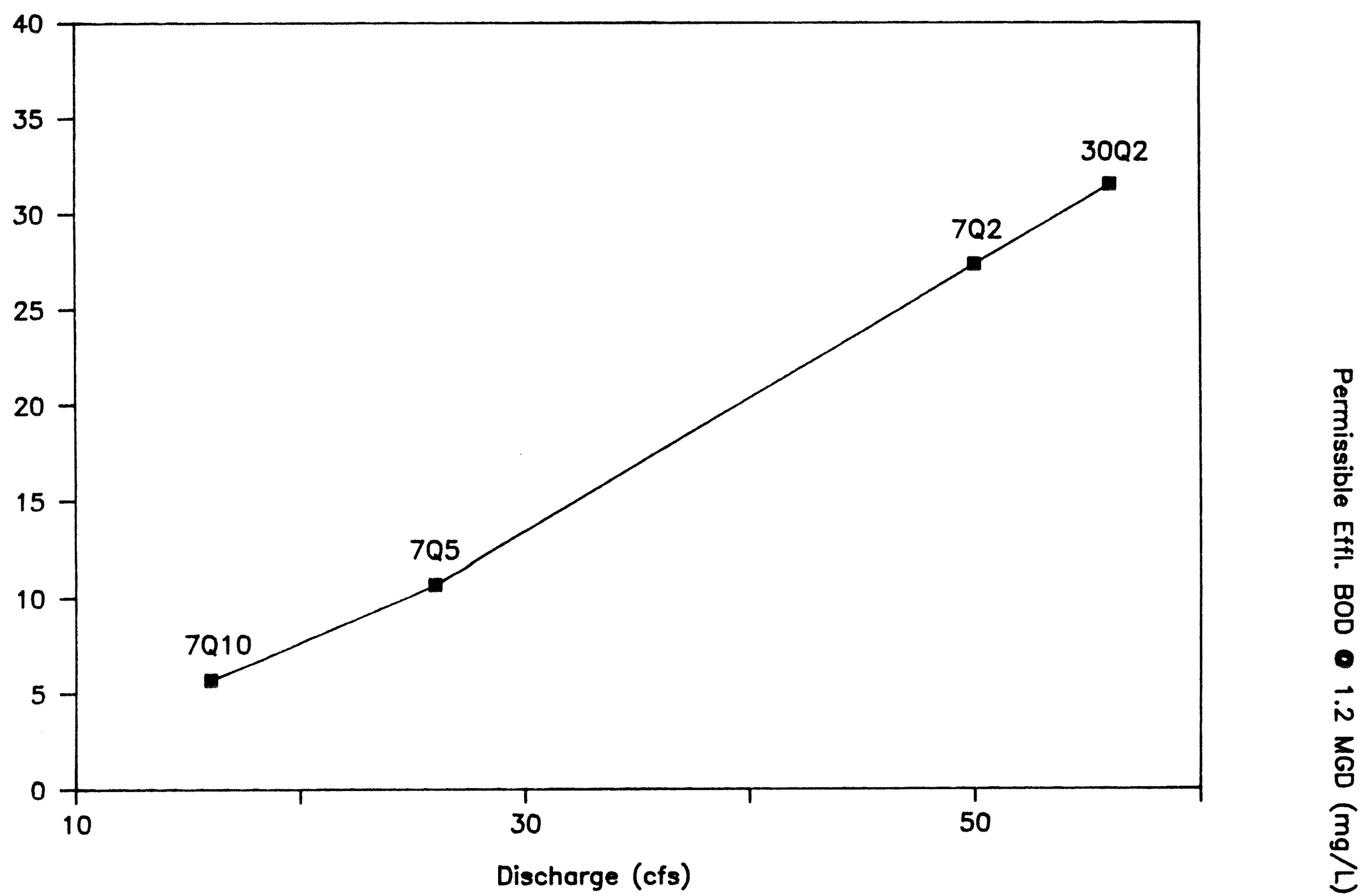


Figure 5. Calculated permissible effluent BOD5 concentration for design flow of 1.2 MGD for various Colville River discharge conditions and targeted Class A dissolved oxygen standard of 8 mg/L.

Table 6. Dissolved Oxygen Deficit Allocation for Various Low-Flow (1) Scenarios.

	Upstream River Discharge (CFS)							
	16	26	50	56	64	71	79	97
Low Flow Duration and Recurrence Interval (1)	7Q10	7Q5	7Q2	30Q2	60Q2	90Q2	120Q2	183Q2
Saturation Concentration (2)	8.41	8.46	8.60	8.63	8.69	8.72	8.78	8.89
Class A D.O. Standard	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Deficit Available w/o Violation	0.41	0.46	0.60	0.63	0.69	0.72	0.78	0.89
Deficit Due to Uncontrollable Background (3)	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09
Deficit Which Can Be Allocated	0.33	0.38	0.51	0.54	0.60	0.63	0.69	0.80
Less Reserve For Uncertainty (4)	0.16	0.19	0.26	0.27	0.30	0.32	0.35	0.40
Allocatable Deficit	0.16	0.19	0.26	0.27	0.30	0.32	0.35	0.40
Projected Deficit at Permitted BOD Load (5)	2.85	1.76	0.94	0.86	0.78	0.72	0.67	0.55
Permissible Effluent BOD Load (#/day) (6)	57	107	273	316	387	439	517	728
Permissible Effluent BOD Concentration (mg/L) at Permitted Flow of 1.2 MGD	6	11	27	32	39	44	52	73

FOOTNOTES:
1) m-Q-n low flow represents low flow of m-day duration and n-year recurrance interval.
2) Based on temperature data from ambient monitoring, T(deg C)=(Q(cfs))*(-.03322))+21.26
3) Based on ambient monitoring data, background deficit assume equal to 1 percent of saturation.
4) Assumed 50 percent reserve for uncertainty.
5) Based on Streeter-Phelps analysis; see Appendix A for assumptions.
6) Permissible effluent BOD Load estimated as:
(Projected Load)*((Allocatable Deficit)/(Projected Deficit))
where projected load is assumed equal to 1000 #/day based on existing permitted weekly load (Driscoll, et al., 1983).

Table 7. Calculated concentrations of selected parameters in the Colville River resulting from permitted effluent discharge and 7Q10 low river flow.

Parameter	Upstream Concentration (1)	Effluent Concentration (2)	Downstream Concentration (3)	Water Quality Criteria/Standards Acute Aquatic Life	Chronic Aquatic Life	Class A
Fecal coliform (#/100 mL)	50	400	86	--	--	100/200
Residual chlorine (mg/L)	<0.100	0.500	0.052	0.019	0.011	--
Un-ionized ammonia (ug N/L)	1.2	42	3.2	210	41	--
Copper (ug/L)	3	6	3.3	31	20	--
Nickel (ug/L)	<5	26	<5	2,400	260	--
Zinc (ug/L)	1	4	1.3	200	180	--

1) Based on Ecology survey station 1
2) Based on weekly average permit for fecal coliform and residual chlorine. Un-ionized ammonia, copper, nickel, and zinc were based on Ecology survey results.
3) Calculated assuming complete mix of effluent with river based on 7Q10 discharge rate of 16 cfs and permitted effluent discharge of 1.2 MGD. Un-ionized ammonia estimated based on mass balance of total ammonia and in-river temperature of 21°C and pH of 8.0 based on ambient monitoring data (Ecology, unpubl. data).

The preceding evaluation indicates that some currently permitted effluent characteristics will probably cause undesirable degradation of the Colville River at critical low flow conditions. In particular, permitted BOD loading will probably result in D.O. sag below the Class A standard. Also, permitted residual chlorine concentrations will probably cause exceedence of chronic and acute aquatic life criteria. The D.O. standard and residual chlorine criteria violations are both predicted to occur at river flows less than 79 cfs (120Q2). Therefore, maintenance at the Class A standard and aquatic life criteria would require permit reduction in both BOD and residual chlorine loads to the river at flows less than 79 cfs (120Q2), which generally occurs between July and November.

Sediment Metals. Table 8 presents the results of metals analyses. The stream sediment at all four sites were of similar texture: primarily sandy gravel with some silt and clay. Metals concentrations were found to be correlated with the fine silt and clay fraction (Table 9). Comparisons of upstream with downstream concentrations of sediment metals did not reveal enrichment below the WTP discharge, even when corrected for fines content (Table 8). This finding is consistent with the relatively low levels of metals found in the effluent and river water, as discussed above.

Benthic Macroinvertebrates. The relative abundance and species diversity of benthic macrofauna are often used as a direct indicator of water quality status. Inputs of organic wastes typically reduce the diversity and increase the biomass of the most tolerant species (Welch, 1980). The observed diversity upstream and downstream from the WTP discharge did not reveal any obvious reduction from the waste input (Table 10). In general, the macroinvertebrate diversity suggests a moderately polluted condition for all stations including upstream of the WTP input. Sediment texture at all sites was very similar and can be described as sandy gravel, ranging from 97 to 99 percent sand and gravel (Table 8). Therefore, comparisons of benthic macroinvertebrate populations between samples is not expected to be influenced by variation in sediment texture.

CONCLUSIONS AND RECOMMENDATIONS

- WTP effluent dilution occurs over a relatively long dilution zone (>300 feet) relative to Ecology guidelines.

- Potential effluent dilution at low river flow (7Q10 low flow) is relatively low (approximately 9:1) compared with Ecology guidelines (100:1).

- Water quality data did not indicate substantial degradation downstream from the initial effluent dilution zone during the Ecology survey. Depletion of dissolved oxygen was observed primarily within the dilution zone, probably due to low dissolved oxygen concentrations in the effluent.

- Dissolved oxygen depletion below the Class A standard is predicted under permitted monthly BOD loading (600 lbs./day) at river flows less than 79 cfs (120Q2). Therefore, reductions in the permitted BOD loading at river flows less than 79 cfs (120Q2) are recommended. Diversion of up to 90 percent of the effluent may be necessary at river flow

Table 8. Colville River receiving water study: sediment texture and metals concentrations.

	Sampling Station			
	1-N	2-N	3-N	6
SEDIMENT TEXTURE				
Percent Gravel (>2mm)	68.07	74.20	81.07	56.99
Percent Sand (62um-2mm)	30.95	24.74	15.73	41.00
Percent Silt (4-62um)	0.44	0.65	2.39	1.42
Percent Clay (<4um)	0.50	0.26	0.45	0.61
TOTAL METALS CONCENTRATION (mg/Kg dry wt)				
Cadmium	0.035	0.047	0.015	0.034
Chromium	2.24	2.86	2.22	2.51
Copper	1.4	2.15	1.59	1.61
Lead	1.94	2.09	1.96	1.73
Nickel	3.11	4.02	3.3	2.93
Zinc	11.2	15.4	11.2	12.2
NORMALIZED METALS CONCENTRATION (mg/Kg Silt+Clay)				
Cadmium	4	4	0.5	2
Chromium	229	270	69	125
Copper	143	203	50	80
Lead	198	197	61	86
Nickel	317	379	103	146
Zinc	1,143	1,453	349	604

Table 9. Colville River receiving water study: sediment metals correlations.

	Gravel	Sand	Silt	Clay	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
Gravel	1									
Sand	-0.992**	1.000								
Silt	0.121	0.187	1.000							
Clay	0.458	0.389	0.061	1.000						
Cadmium	0.138	0.199	0.758	0.169	1.000					
Chromium	0.017	0.030	0.170	0.351	0.642	1.000				
Copper	0.063	0.047	0.039	0.658	0.354	0.852*	1.000			
Lead	0.621	0.534	0.069	0.897*	0.073	0.107	0.337	1.000		
Nickel	0.312	0.258	0.071	0.966**	0.256	0.528	0.817*	0.763	1.000	
Zinc	0.006	0.001	0.178	0.579	0.601	0.947**	0.939**	0.286	0.746	1.000

NOTES:

*Indicates Significant Correlation at 90 Percent Confidence Level
**Indicates Significant Correlation at 95 Percent Confidence Level

Table 10. Relative abundance (1) of various invertebrate taxononomic groups in the Colville River.

Taxonomic Group	Station One	Station Three	Station Six
Cladocera (Water Fleas)	--	A	P
Diptera (Flies)			
Chlronomidae	A	A	A
Empididae	--	--	P
Ephemeroptera (May Fly)	P	P	C
Hemiptera (True Bugs)	--	P	--
Hydracarina (Water Mites)	_	--	P
Oligachaeta (Worms)	--	C	--
Pelecypoda (Bivalves)	P	--	--
DIVERSITY INDEX D(2)	1.1	1.9	1.3

FOOTNORES:

1) Composite sample of five sites across the stream, using hand net with pooled material picked for 10 minutes.

Abundance Categories: A = Abundant (>15 organisms)
C = Common (5-15 organisms)
P - Present (1-5 organisms)

2) Based on Shannon and Weaver, 1963. Wilhm and Dorris (1968) suggest the folowing guideline for water quality status:

Heavy Pollution:	D < 1.0
Moderate Pollution	D = 1.0 - 3.0
Clean Water	D > 3.0

less than 56 cfs (30Q2) to maintain the Class A standard if effluent BOD concentrations exceed 30 mg/L at the permitted discharge rate. A maximum effluent discharge of 1.2 MGD (1.9 cfs) is acceptable under the existing permit when the upstream river discharge exceeds 79 cfs (120Q2), which generally occurs from December through June.

- Residual chlorine concentrations are expected to be elevated above the chronic and acute aquatic life criteria at currently permitted effluent concentrations and permitted effluent discharge rates at the 7Q10 low river flow. River flows less than 79 cfs (120Q2) are predicted to result in chronic aquatic life criteria exceedence under the existing permit. Dechlorination of effluent during conditions of low river flow (< 79 cfs) is recommended in order to avoid exceedence of aquatic life criteria.

- Metals loadings from the WTP were found to increase water column concentrations, but no increases in sediment concentrations were observed over upstream conditions. Water column and effluent concentrations were within water quality criteria for aquatic life and human health. However, sampling to date has been limited and additional studies would be required to confidently characterize effluent metals loadings.

- Diversity of benthic macroinvertebrates suggests a moderately polluted condition upstream and downstream from the discharge. Effluent discharge was not found to degrade the water quality status based on macrofauna diversity.

REFERENCES

APHA, AWWA, WPCF, 1985. Standard methods for the examination of water and wastewater. Washington, D.C. 1268 pp.

Driscoll, E.D., J.L. Mancini, and P.A. Mangarella, 1983. Technical guidance manual for performing wasteload allocations. Book II Streams and Rivers. Chapter I Biochemical Oxygen Demand/Dissolved Oxygen. Final Report for Office of Water Regulation and Standards, Monitoring and Data Support Division, Monitoring Branch, U. S. Environmental Protection Agency, September, 1983.

Ecology, 1985. Criteria for Sewage Works Design, Washington Department of Ecology, DOE-78-5.

Hallinan, P., 1988. Metals concentrations found during Ecology inspections of municipal WTPs. Memo to J. Bernhardt, April 11, 1988. Department of Ecology EILS.

Hallock, D., 1988. 1988 Water Quality Index. Memo to J. Bernhardt, June 10, 1988. Department of Ecology, EILS.

Heffner, M., 1988. Colville Wastewater Treatment Plant Class II Inspection, September 22-23, 1987. Department of Ecology, EILS, August, 1988.

Mills, W.B., D.B. Porcella, M.J. Ungs, S.A. Gherini, K.V. Summers, L. Mok, G.L. Rupp, and G.L. Bowie, *et al.*, 1985. A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water. EPA 600/6-85-002a.

Shannon, C.E., and W. Weaver, 1963. The Mathematical Theory of Communication. University of Illinois Press, Urbana.

U. S. Environmental Protection Agency, 1983. Methods for chemical analysis of water and wastes. Environmental Monitoring Supply Laboratory, Cincinnati, OH., EPA-600/4-79-020.

Welch, E.B., 1980. Ecological Effects of Wastewater. Cambridge University Press.

Wilhm, J., and T. Dorris, 1968. Biological Parameters for Water Quality Criteria. Bio. Sci. 18:477-81.

Williams, J.R. and H.E. Pearson, 1985. Streamflow statistics and drainage basin characteristics for the Southwestern and Eastern regions, Washington. U.S. Geological Survey Open File Report 84-145-B.

APPENDIX A

DISSOLVED OXYGEN SAG PREDICTIONS BASED ON STREETER-PHELPS ANALYSIS
(Mills, *et al.*, 1985)

COLVILLE RIVER DISSOLVED OXYGEN PREDICTIONS; 7Q10 LOW FLOW
STREETER-PHELPS ANALYSIS OF CRITICAL DISSOLVED OXYGEN SAG

INPUT **

1.	UPSTREAM DISCHARGE (cfs)....................................:	16
2.	EFFLUENT DISCHARGE (cfs)....................................:	1.86
3.	UPSTREAM DO CONCENTRATION (mg/L)............................:	8.32
4.	EFFLUENT DO CONCENTRATION...................................:	2.00*
5.	UPSTREAM CBOD (Ultimate) CONCENTRATION (mg/L)...............:	1.5
6.	EFFLUENT CBOD (Ultimate) CONCENTRATION (mg/L)...............:	147
7.	UPSTREAM NBOD CONCENTRATION (mg/L)..........................:	0.2
8.	EFFLUENT NBOD CONCENTRATION (mg/L)..........................:	2.6
9.	STREAM VELOCITY (fps).......................................:	0.98
10.	STREAM DEPTH (ft)...:	0.46
11.	STREAM SLOPE (ft/ft)..:	0.00088
12.	AVERAGE ELEVATION OF RIVER REACH (FT MSL)...................:	1540
13.	STREAM TEMPERATURE (deg C)..................................:	20.7
14.	REAERATION RATE (Base e) AT 20 deg C (day^-1)...............:	4

Reference	Applic. Vel (fps)	Applic. Dep (ft)	Suggested Value
Churchill	1.5 - 6	2 - 50	41.70
O'Connor and Dobbins	0.1 - 1.5	2 - 50	41.12
Owens	0.1 - 6	1 - 2	89.63
Tsiviglou-Wallace	0.1 - 6	0.1 - 2	4.02

15.	BOD DECAY RATE (Base e) AT 20 deg C (day^-1)................:	1

CALCULATED VALUES **

1.	DO SATURATION CONCENTRATION (mg/L)..........................:	8.41
2.	INITIAL DO CONCENTRATION (mg/L).............................:	7.67
3.	INITIAL DO DEFICIT (mg/L)...................................:	0.74
4.	INITIAL DOWNSTREAM BOD CONCENTRATION (mg/L).................:	17.08
5.	REARATION RATE AT STREAM TEMPERATURE (day^-1)...............:	4.07
6.	BOD DECAY RATE AT STREAM TEMPERATURE (day^-1)...............:	1.03
7.	TRAVEL TIME TO CRITICAL DO CONCENTRATION (days).............:	0.41
8.	DISTANCE TO CRITICAL DO CONCENTRATION (miles)...............:	6.52
9.	CRITICAL DO DEFICIT (mg/L)..................................:	2.85
10.	CRITICAL DO CONCENTRATION (mg/L)............................:	5.56

****

*Assumed effluent D.O. concentration to reflect diurnal minimum due to night-time respiration in lagoons.

COLVILLE RIVER DISSOLVED OXYGEN PREDICTIONS; 7Q5 LOW FLOW
STREETER-PHELPS ANALYSIS OF CRITICAL DISSOLVED OXYGEN SAG

INPUT **

1.	UPSTREAM DISCHARGE (cfs)....................................:	26
2.	EFFLUENT DISCHARGE (cfs)....................................:	1.86
3.	UPSTREAM DO CONCENTRATION (mg/L)............................:	8.37
4.	EFFLUENT DO CONCENTRATION...................................:	2.00
5.	UPSTREAM CBOD (Ultimate) CONCENTRATION (mg/L)...............:	1.5
6.	EFFLUENT CBOD (Ultimate) CONCENTRATION (mg/L)...............:	147
7.	UPSTREAM NBOD CONCENTRATION (mg/L)..........................:	0.2
8.	EFFLUENT NBOD CONCENTRATION (mg/L)..........................:	2.6
9.	STREAM VELOCITY (fps).......................................:	1.1
10.	STREAM DEPTH (ft)...:	0.62
11.	STREAM SLOPE (ft/ft)..:	0.00088
12.	AVERAGE ELEVATION OF RIVER REACH (FT MSL)...................:	1540
13.	STREAM TEMPERATURE (deg C)..................................:	20.4
14.	REAERATION RATE (Base e) AT 20 deg C (day^-1)...............:	4.5

Reference	Applic. Vel (fps)	Applic. Dep (ft)	Suggested Value
Churchill	1.5 - 6	2 - 50	28.31
O'Connor and Dobbins	0.1 - 1.5	2 - 50	27.84
Owens	0.1 - 6	1 - 2	55.75
Tsiviglou-Wallace	0.1 - 6	0.1 - 2	4.52

15.	BOD DECAY RATE (Base e) AT 20 deg C (day^-1)................:	1

CALCULATED VALUES **

1.	DO SATURATION CONCENTRATION (mg/L)..........................:	8.46
2.	INITIAL DO CONCENTRATION (mg/L).............................:	7.95
3.	INITIAL DO DEFICIT (mg/L)...................................:	0.51
4.	INITIAL DOWNSTREAM BOD CONCENTRATION (mg/L).................:	11.56
5.	REARATION RATE AT STREAM TEMPERATURE (day^-1)...............:	4.54
6.	BOD DECAY RATE AT STREAM TEMPERATURE (day^-1)...............:	1.02
7.	TRAVEL TIME TO CRITICAL DO CONCENTRATION (days).............:	0.38
8.	DISTANCE TO CRITICAL DO CONCENTRATION (miles)...............:	6.79
9.	CRITICAL DO DEFICIT (mg/L)..................................:	1.76
10.	CRITICAL DO CONCENTRATION (mg/L)............................:	6.69

****

COLVILLE RIVER DISSOLVED OXYGEN PREDICTIONS; 7Q2 LOW FLOW
STREETER-PHELPS ANALYSIS OF CRITICAL DISSOLVED OXYGEN SAG

INPUT **

1.	UPSTREAM DISCHARGE (cfs)....................................:	50
2.	EFFLUENT DISCHARGE (cfs)....................................:	1.86
3.	UPSTREAM DO CONCENTRATION (mg/L)............................:	8.51
4.	EFFLUENT DO CONCENTRATION...................................:	2.00
5.	UPSTREAM CBOD (Ultimate) CONCENTRATION (mg/L)...............:	1.5
6.	EFFLUENT CBOD (Ultimate) CONCENTRATION (mg/L)...............:	147
7.	UPSTREAM NBOD CONCENTRATION (mg/L)..........................:	0.2
8.	EFFLUENT NBOD CONCENTRATION (mg/L)..........................:	2.6
9.	STREAM VELOCITY (fps).......................................:	1.3
10.	STREAM DEPTH (ft)...:	0.97
11.	STREAM SLOPE (ft/ft)..:	0.00088
12.	AVERAGE ELEVATION OF RIVER REACH (FT MSL)...................:	1540
13.	STREAM TEMPERATURE (deg C)..................................:	19.6
14.	REAERATION RATE (Base e) AT 20 deg C (day^-1)...............:	5.3

Reference	Applic. Vel (fps)	Applic. Dep (ft)	Suggested Value
Churchill	1.5 - 6	2 - 50	15.74
O'Connor and Dobbins	0.1 - 1.5	2 - 50	15.47
Owens	0.1 - 6	1 - 2	27.24
Tsiviglou-Wallace	0.1 - 6	0.1 - 2	5.34

15.	BOD DECAY RATE (Base e) AT 20 deg C (day^-1)................:	1

CALCULATED VALUES ***

1.	DO SATURATION CONCENTRATION (mg/L)..........................:	8.60
2.	INITIAL DO CONCENTRATION (mg/L).............................:	8.28
3.	INITIAL DO DEFICIT (mg/L)...................................:	0.32
4.	INITIAL DOWNSTREAM BOD CONCENTRATION (mg/L).................:	6.99
5.	REARATION RATE AT STREAM TEMPERATURE (day^-1)...............:	5.25
6.	BOD DECAY RATE AT STREAM TEMPERATURE (day^-1)...............:	0.98
7.	TRAVEL TIME TO CRITICAL DO CONCENTRATION (days).............:	0.34
8.	DISTANCE TO CRITICAL DO CONCENTRATION (miles)...............:	7.25
9.	CRITICAL DO DEFICIT (mg/L)..................................:	0.94
10.	CRITICAL DO CONCENTRATION (mg/L)............................:	7.66

****

COLVILLE RIVER DISSOLVED OXYGEN PREDICTIONS; 30Q2 LOW FLOW
STREETER-PHELPS ANALYSIS OF CRITICAL DISSOLVED OXYGEN SAG

INPUT **

1.	UPSTREAM DISCHARGE (cfs).................................:	56
2.	EFFLUENT DISCHARGE (cfs).................................:	1.86
3.	UPSTREAM DO CONCENTRATION (mg/L).........................:	8.55
4.	EFFLUENT DO CONCENTRATION................................:	2.00
5.	UPSTREAM CBOD (Ultimate) CONCENTRATION (mg/L)............:	1.5
6.	EFFLUENT CBOD (Ultimate) CONCENTRATION (mg/L)............:	147
7.	UPSTREAM NBOD CONCENTRATION (mg/L).......................:	0.2
8.	EFFLUENT NBOD CONCENTRATION (mg/L).......................:	2.6
9.	STREAM VELOCITY (fps)....................................:	1.3
10.	STREAM DEPTH (ft)..:	1.1
11.	STREAM SLOPE (ft/ft).....................................:	0.00088
12.	AVERAGE ELEVATION OF RIVER REACH (FT MSL)................:	1540
13.	STREAM TEMPERATURE (deg C)...............................:	19.4
14.	REAERATION RATE (Base e) AT 20 deg C (day^-1)............:	5.3

Reference	Applic. Vel (fps)	Applic. Dep (ft)	Suggested Value
Churchill	1.5 - 6	2 - 50	12.75
O'Connor and Dobbins	0.1 - 1.5	2 - 50	12.81
Owens	0.1 - 6	1 - 2	21.59
Tsiviglou-Wallace	0.1 - 6	0.1 - 2	5.34

15.	BOD DECAY RATE (Base e) AT 20 deg C (day^-1).............:	1

CALCULATED VALUES ***

1.	DO SATURATION CONCENTRATION (mg/L).......................:	8.63
2.	INITIAL DO CONCENTRATION (mg/L)..........................:	8.34
3.	INITIAL DO DEFICIT (mg/L)................................:	0.30
4.	INITIAL DOWNSTREAM BOD CONCENTRATION (mg/L)..............:	6.45
5.	REARATION RATE AT STREAM TEMPERATURE (day^-1)............:	5.23
6.	BOD DECAY RATE AT STREAM TEMPERATURE (day^-1)............:	0.97
7.	TRAVEL TIME TO CRITICAL DO CONCENTRATION (days)..........:	0.34
8.	DISTANCE TO CRITICAL DO CONCENTRATION (miles)............:	7.29
9.	CRITICAL DO DEFICIT (mg/L)...............................:	0.86
10.	CRITICAL DO CONCENTRATION (mg/L).........................:	7.77

****